Theoretical investigation of laser pulses propagation dynamic in argon gas : Pressure effect study

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Abstract

This research presents a theoretical study of the phenomenon of laser induced breakdown and plasma generation in argon at different values of the gas pressure .The breakdown is obtained using a focused high intensity laser beam of wavelength 532 nm , pulse duration 8 ns and maximum energy 500 mJ , to irradiate the argon gas over a pressure range varies between 10-760 torr, which is equivalent to 0.013-1.0 atm (Bindhu et al ; 2003). In doing so a modified electron cascade model (Gamal et al , 1999) in applied which depends on the numerical solution of the time dependent Boltzmann equation simultaneously with a set of rate equations that describe the rate of change of the formed excited states density. Assuming the intensity has a Gaussian shape that varies only in time, comparison of the calculated threshold intensity as a function of the gas pressure and the experimentally measured ones showed good agreement over the whole pressure range. This in turn validate the numerical model in investigating the breakdown phenomenon of argon. In addition the study of the variation of the electron energy distribution function(EEDF) and its parameters during the laser pulse as a function of the gas pressure demonstrated the correlation between the physical processes responsible for the gas breakdown and the gas pressure. The study takes also into account the

effect of electron gain and loss processes at the different gas pressure values. To study the plasma propagation in the focal volume the model considered the temporal and spatial variation of the laser intensity in the focal volume, where the calculations are carried out at different values of the laser energy to clarify the relation between the density of the formed plasma and its rate of absorption for the input energy as well as its propagation rate in the focal volume as a function of the laser energy. The result of this study illustrated the increase rate of plasma propagation by increasing the input energy, where it is found that at input energy equals three and half time its threshold energy value ,the plasma propagates to cover the whole Rayleigh range in the backward direction. On the other hand, the study of the effect of gas pressure on the plasma propagation in the focal volume for gas pressure of 1.0, 10.0 and 100.0 atm showed that the most interesting propagation of the plasma occurs at the intermediate region of the gas pressure.